Similar observations were made upon the nitrates derived from the other minerals above mentioned, the actual wave-lengths being in every case determined so that the position of the lines can be open to no doubt whatever.

Ten years ago the erbium earths were considered as the oxide of a single element, but we now know that they consist of the oxides of scandium, ytterbium, thulium, erbium, terbium, holmium, and yttrium. Out of the rich data furnished by the present observations the observers believe they can prove that all those erbium earths whose nitrates give absorption-spectra are not oxides of simple bodies, but mixtures of the oxides of various new elements. Yttrium, as before mentioned, has already been shown by Mr. Crookes to consist of five constituents, and it will be interesting to see what light the workers in Stockholm have thrown upon the nature of some of the remainder.

M. Lecoq de Boisbaudran showed that by fractionation of Soret's X two new substances were arrived at, which he named holmium and dysprosium, but these are now shown to be themselves compound, for one part of dysprosium is not present in thorite of Brevig or cerite of Bastnäs, although present in the mixture called X; in fact, de Boisbaudran's dysprosium lines Dyα, Dyβ, and Dyδ are found to belong to three different elements; and the other constituent, the holmium of de Boisbaudran, is probably made up of no less than four distinct components.

As the introduction of fresh names is rapidly increasing the difficulty of work in this direction, Krüss and Nilson prefer to simply label the components by affixing the letters of the Greek alphabet to already accepted symbols. The metal called by Soret X is therefore constituted as follows:—

	Wave-length of characteristic line in absorption-spectrum of nitrate.
Xα	640·4
Xβ	542·6
Xγ	536·3
Xδ	485·5
Xε	474·5
Xζ	451·5
Xη	428·5

of which

Thorite of Brevig	contains...	Xα, Xδ, Xη.
,, Arendal	,, ...	Xβ, Xγ, Xε, Xζ, Xη.
Wöhlerite of Brevig	,, ...	Xγ, Xζ, Xη.
Cerite of Bastnäs	,, ...	Xα, Xη.
Fergusonite of Arendal	,, ...	Xβ, Xγ, Xδ, Xε, Xζ, Xη.
Fergusonite of Ytterby and euxenite of Arendal and Hitterö contain	... ...	Xα, Xβ, Xγ, Xδ, Xε, Xζ, Xη.

We are now accustomed to distinguish as erbium that body whose nitrate solution exhibits, in addition to a large number of lines in the violet and ultra-violet, two principal lines of wave-lengths 523·1 and 654·7 respectively, of which the former is the most intense. But in euxenite of Hitterö much greater difference is shown, one being extremely strong, while the other is barely visible; therefore here again the observers consider themselves in face of at least two elements, Erα and Erβ, one giving 523·1 and the other 654·7. Moreover, they have succeeded in separating the two almost completely by a method of fractionation similar to that employed by Mr. Crookes.

Cleve, in 1879, gave the name of thulium to the metal whose oxide formed the strongest base present in the mixture of erbium earths; and its salts, according to Thalèn, exhibit two absorption-bands, 684·0 and 465·0, of which the former is the most intense. Again, the variations are found to be too great for the supposition of a single earth to be tenable, one line being entirely absent in fergusonite and thorite of Arendal, while the other is strong; hence thulium must also consist of two ingredients, Tmα and Tmβ.

The observations with regard to didymium are all the more interesting as entirely confirming Mr. Crookes's statements, and Drs. Krüss and Nilson even go further in proving either that our interpretations of the indications of spectrum analysis are grossly wrong or that didymium is composed of not less than nine distinct elements. Dr. Auer von Welsbach's symbols for praseodymium and neodymium, the two constituents of didymium which he actually separated, are discarded, and the same nomenclature adopted as in the case of holmium.

	Characteristic line in absorption-spectrum of nitrate solution.
Diα	728·3
Diβ	679·6
Diγ	579·2 and 575·4
Diδ	521·5
Diε	512·2
Diζ	482·0
Diη	469·0
Diθ	445·1
Diι	444·7

The name samarium was given by M. de Boisbaudran to an element identical with Marignac's Yβ, an ingredient of the old didymium. The nitrate of this metal gives seven absorption-bands according to Thalèn, but it is surprising that in thorite and euxenite of Arendal the line 416·7 is tolerably strong, and even very strong, without another samarium line to be seen in the spectrum; the conclusion is inevitable that there must be in this substance a constituent whose nitrate gives the line 416·7, and to this the name Smα is given, all other samarium lines being provisionally supposed to belong to Smβ.

The main result of this splendid work, therefore, appears to be that, instead of holmium, erbium, thulium, didymium, and samarium, we must, if we follow Krüss and Nilson, recognize the existence of at least twenty-two new elements, the fate of some of which may be, in the near future, to be subjected to still further subdivision. If we add to these the results previously obtained by Mr. Crookes with respect to yttrium, the astounding revelation is presented to us that instead of six we find ourselves in face of twenty-seven, or a clear gain of at least twenty-one new elements.

But now comes the vital question—Are these really new elements, or are they only different molecular aggregations of the atoms of a few, as suggested by Mr. Crookes? It certainly seems very remarkable that so large a number of elements should be crowded together about the central series of the periodic system, and we appear to have a repetition of the same phenomenon, in a much intensified degree, as obtains in the cases of nickel and cobalt, rhodium, ruthenium, and palladium, and of iridium, osmium, and platinum. It may, however, be interesting in this connexion to remember that this precise state of things was predicted by Mendelejeff himself (*Ann. Chem. Pharm.* Suppl. 8, p. 158), and in no way militates against the new element theory. Krüss and Nilson, rather than be obliged to have recourse to the introduction of new or auxiliary theories of spectrum analysis, prefer to rest upon the simpler and apparently more straightforward assumption that these substances, whose nitrate spectra show such marked differences, are indeed *bonâ fide* new elements. The accuracy of this view will doubtless be strongly contested, but in any case the result appears likely to be equally striking; for, if future work shows its want of accordance with facts, then an entirely new field of research has been opened, and the generally accepted ideas of the structure of matter must of necessity undergo a complete metamorphosis.

A. E. TUTTON.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 16.—"On Figures of Equilibrium of Rotating Masses of Fluid." By G. H. Darwin, M.A., LL.D., F.R.S., Fellow of Trinity College and Plumian Professor in the University of Cambridge.

The intention of this paper is, first, to investigate the forms which two masses of fluid assume when they revolve in close proximity about one another, without relative motion of their parts; and secondly, to obtain a representation of the single form of equilibrium which must exist when the two masses approach so near to one another as just to coalesce into a single mass.

When the two masses are far apart the solution of the problem is simply that of the equilibrium theory of the tides. Each mass may, as far as the action on the other is concerned, be treated as spherical. When they are brought nearer to one another this approximation ceases to be sufficient, and the departure from sphericity of each mass begins to exercise a sensible deforming influence on the other.

The actual figure assumed by either mass may be regarded as a deformation due to the influence of the other considered as a sphere, on which is superposed the sum of an infinite series of deformations of each due to the deformation of the other and of itself.

But each mass is deformed, not only by the tidal action of the other, but also by its own rotation about an axis perpendicular to its orbit. The departure from sphericity of either body due to rotation also exercises an influence on the other and on itself, and thus there arises another infinite series of deformations.

It is shown in the paper how the summations of these two kinds of reflected influences are to be made, by means of the solution of certain linear equations for finding three sets of coefficients.

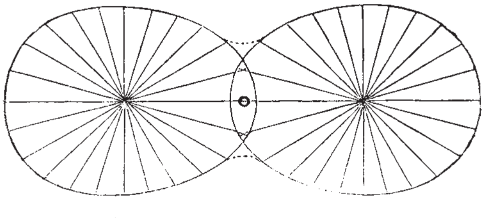
The first set of coefficients are augmenting factors, by which the tide of each order of harmonics is to be raised above the value which it would have if the perturbing mass were spherical. The second set correspond to one part of the rotational effect, and belong to terms of exactly the same form as the tidal terms, with which they ultimately fuse. The third set correspond to the rest of the rotational effect, and appertain to a different class of deformation, which are in fact sectorial harmonics of different orders. The term of the second order represents the ellipticity of the mass due to rotation, augmented, however, by mutual influence. All the terms of this class, except the second, are very small; their existence is, however, interesting.

From the consideration that the repulsion due to centrifugal force shall exactly balance the attraction between the two masses, the angular velocity of the system is found. It is greater than would be the case if the masses were spherical.

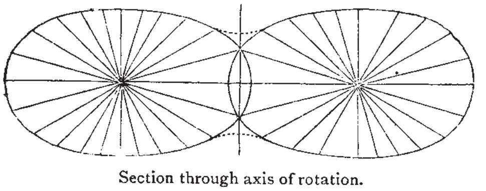
The theory here sketched is applied in the paper numerically, and illustrated graphically in several cases.

When the masses are equal to one another they are found to be shaped like flattened eggs, and the two small ends face one another. Two figures are given, in one of which the small ends nearly touch, and in the other where they actually cross. In the latter case, as two portions of matter cannot occupy the same space, the reality must consist of a single mass of fluid consisting of two bulbs joined by a neck, somewhat like a dumb-bell. In the figure conjectural lines are inserted to show how the overlapping of the masses must be replaced by the neck of fluid.

FIG. 1



Section perpendicular to axis of rotation.



Section through axis of rotation.

A comparison is also made between the Jacobian ellipsoid of equilibrium with three unequal axes and the dumb-bell. It appears that with the same moment of momentum the angular velocity is nearly the same in the two figures, but the kinetic energy is a little less in the dumb-bell. The intrinsic energy of the dumb-bell is, however, greater than that of the ellipsoid, so that the total energy of the dumb-bell is slightly greater than that of the ellipsoid.

Sir William Thomson has remarked on the "gap between the unstable Jacobian ellipsoid . . . . . and the case of the smallest moment of momentum consistent with stability in two equal detached portions." "The consideration," he says, "of how to fill up this gap with intermediate figures is a most attractive question, towards answering which we at present offer no contribution."[1] This paper is intended to be such a contribution, although an imperfect one.

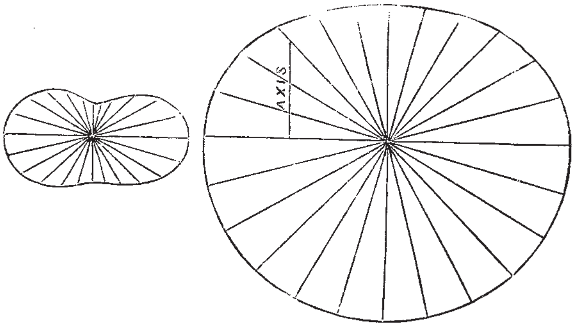
M. Poincaré has made an admirable investigation of the forms of equilibrium of a single rotating mass of fluid, and has specially considered the stability of Jacobi's ellipsoid.[2] He has shown by a difficult analytical process, that when the ellipsoid is moderately elongated, instability sets in by a furrowing of the ellipsoid along a line which lies in a plane perpendicular to the longest axis. It is, however, extremely remarkable that the furrow is not symmetrical with respect to the two ends, and there thus appears to be a tendency to form a dumb-bell with unequal bulbs.

M. Poincaré's work seemed so important that, although the figures above referred to were already drawn a year ago, this paper was kept back in order that an endeavour might be made to apply the principles enounced by him, concerning the stability of such systems. The attempt, which proved abortive on account of the imperfection of approximation of spherical harmonic analysis, is given in the appendix to the paper, because, notwithstanding its failure, it presents features of interest.

The calculations in this paper being made by means of spherical harmonic analysis, it is necessary to consider whether this approximate method has not been pushed too far in the computation of figures of equilibrium which depart considerably from spheres. A rough criterion of the applicability of the analysis is derived from a comparison between the two values of the ellipticity of an isolated revolutional ellipsoid of equilibrium as derived from the rigorous formula and from spherical harmonic analysis. As judged by this criterion, which is necessarily in some respects too severe, the figures drawn appear to present a fair approximation to accuracy.

Since, as above stated, the rigorous method of discussing the stability of the system fails, certain considerations are adduced which bear on the conditions under which there is a form of equilibrium consisting of two fluid masses in close proximity, and it appears that there cannot be such a form, unless the smaller of the two masses exceeds about one-thirtieth of the larger. It seemed therefore worth while to find to what results the analysis would lead: when two masses, one of which is twenty-seven times as great as the other, are brought close together. As judged by this criterion the computed result must be very far from the truth, but as the criterion is too severe, it seemed worth while to give the figure. The smaller mass is found to be deeply furrowed in a plane parallel to the axis of rotation, so as to be shaped like a dumb-bell, and although this result can only be taken to represent the truth very roughly, yet it cannot be entirely explained by the imperfection of the analytical method employed. It appears then as if the smaller body were on the point of separating into two masses, in the same sort of way that the Jacobian ellipsoid may be traced through the dumb-bell shape until it becomes two masses.

FIG. 2.



Ratio of masses 1 : 27. Upper half of figures section through axis of rotation. Lower half section perpendicular to axis.

M. Poincaré has commented in his paper on the possibility of the application of his results, so as to throw light on the genesis of a satellite according to the nebular hypothesis, and this nvestigation was undertaken with such an expectation. He remarks, however, that the conditions for a separation from a mass which is strongly concentrated at its centre, are necessarily very different from those which he has treated mathematically.

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[1] Thomson and Tait, "Natural Philosophy" (1883), § 778 (i). He also remarks elsewhere that by thinning a Jacobian ellipsoid in the middle, we shall get a figure of the same moment of momentum and less kinetic energy.

[2] *Acta Math.* vii. 3 and 4, 1885.

However, both his investigation and the considerations adduced here seem to show that, when a portion of the central body becomes detached through increasing angular velocity, the portion should bear a far larger ratio to the remainder than is observed in our satellites, as compared with their planets; and it is hardly probable that the heterogeneity of the central body can make so great a difference in the results as would be necessary if we are to make an application of these ideas.

It seems then at present necessary to suppose that after the birth of a satellite, if it takes place at all in this way, a series of changes occur which are still quite unknown.

PARIS.

Academy of Sciences, August 1.—M. Janssen in the chair.—On the silicates of thorine, by MM. L. Troost and L. Ouvrard. It was lately shown by the authors that the study of the double phosphates formed by thorine and zircon with phosphoric acid and potassa or soda furnished no argument for associating thorine with zircon. Their further researches on the combinations of thorine and silica have yielded a compound substance, in which this base seems to be still further removed from zircon. The silicates of thorine were prepared by heating a mixture of silica and thorine with the chloride of calcium used as a solvent, and by varying the conditions two silicates were obtained, differing entirely in their composition and crystalline form. The crystals belong to the orthorhombic system, with density 6·82 at 16° C., analysis yielding 18·01 silica and 81·80 thorine. This compound corresponds to the formula $2ThO . SiO_2$ ($Th = 58·1$), or $Th'O_2 . SiO_2$ ($Th' = 116·2$). There is no isomorphism between this silicate of thorine and zircon $ZrO_2 . SiO_2$; but here thorine may be regarded as playing the part of a bioxide. This conclusion has been confirmed by the recent experiments of MM. Krüss and Nilson, who, when determining the vapour-density of thorium, obtained numbers approaching, but always inferior to, that corresponding to the formula $Th'Cl_2$.—New fluorescences with well-marked spectral bands, by M. Lecoq de Boisbaudran. The new fluorescences here described are specially remarkable both for the number and the position of their distinct rays. They are often very bright, and are obtained by taking as agents the oxides of Sm, *Zα*, *Zβ*, and as solid solvents alumina or gallina. Alumina with 1/50 of samarine shows a red, an orange, and a green band, whose positions differ little from those occupied by bands obtained from the inversion of the induction-spark on a solution of chloride of samarium. The red is extremely weak, the orange more visible, the green easily distinguished, although less luminous than the orange.—Fluorescence of spinel, by M. Lecoq de Boisbaudran. The natural spinels give both a red fluorescence, whose spectrum has been carefully described by M. Edm. Becquerel, and also occasionally a greenish fluorescence. It is here shown that the former is due to the presence of chromium, the latter to that of manganese. By introducing 1/1000 of MnO into the composition of artificial spinel, the beautiful green fluorescence gives the same green band, but considerably more intense. By replacing the manganese with 1/100 of oxide of chromium, there is developed a magnificent red fluorescence presenting all the characters of that of the ordinary natural spinels.—Heat of formation of some crystallized tellurides, by M. Ch. Fabre. It is shown that several metallic tellurides may be obtained by heating in nitrogen a mixture of powdered tellurium and filings of the metal. The tellurides of iron, nickel, cobalt, and thallium not hitherto obtained, are crystallized, resisting hydrochloric acid and sulphuric acid at a low temperature, but slowly changing in a moist atmosphere. Reduced to a fine powder they are easily dissolved in bromine and the water of bromine yielding the corresponding bromide, hydrobromic acid, and tellurous acid. A comparison of the heats of formation of the crystallized tellurides and selenides seems to show that in the same group, according as the equivalent weight of the metalloid combined with the metal increases, the quantity of heat liberated by the combination diminishes. But in order to verify this hypothesis, it would be necessary to determine the heat of formation of the corresponding crystallized sulphides.—On the succinimidoacetic and camphorimidoacetic ethers, by MM. Alb. Haller and G. Arth. In order to obtain these ethers, the authors have employed the sodified derivatives of succinimide and camphorimide, the latter behaving like its analogues in the presence of the alkaline metals.—On a new isomere of benzine, by M. G. Griner. Besides the dipropargyle belonging to the fatty series discovered by M. L. Henry, the author has obtained another isomere of benzine, which does not combine with ammoniacal cuprous chloride, and consequently is not acetylenic. Its simplest formula would seem to be $CH_2—C\equiv C—C\equiv C—CH_3$.—Remarks in connexion with the observations of M. Grawitz on the preparation of the chromates of aniline and their applications, by MM. Ch. Girard and L. L'Hote. The authors repeat that they were the first to isolate and study the bichromate of aniline, a crystalline salt, of which they gave the formula and chemical properties, and from which they have succeeded in preparing certain colours such as mauveine, pheno-safranine, violaniline, &c.—On the effects of salting on pig's flesh affected by charbon, by M. F. Peuch. The experiments here described show that even in thoroughly salted bacon the charbon is not killed, but its virulence is destroyed.—On a new microbe determining indigotic fermentation and the production of blue indigo, by M. E. Alvarez. The author's experiments show that indigo is a product of fermentation determined by a special microbe greatly resembling those of pneumonia and rhinosclerome, which also have the power of setting up indigotic fermentation. The microbe of indigo also possesses pathologic properties determining either a passing local inflammation, or even rapid death with congestions of the visceræ and fibrine exudations.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

A New Mode of Geometrical Demonstration, with Examples; D. Maver (Brown, Aberdeen).—Terra: A. A. Anderson (Reeves and Turner).—Annales de l'Observatoire de Nice, tome ii. (Paris).—Food Adulteration and its Detection: J. P. Battershall (Spon).—Electricity: W. Larden (Longmans).—British Dogs, Nos. 9 and 10: H. Dalziel (Gill).—Bees and Bee-keeping, vol. ii. parts 9, 10, 11: F. R. Cheshire (Gill).—McGill University Annual Calendar, Faculty of Medicine (Montreal).—On the Education of Engineers: H. Dyer (Munro, Glasgow).—Hints to Meteorological Observers, 2nd edition (W. Marriott (Stanford).—Archives Néerlandaises des Sciences Exactes et Naturelles, xxi. (Harlem).—Brain, part xxxviii. (Macmillan).—Quarterly Journal of the Royal Meteorological Society, April (Stanford).—Meteorological Record, vol. vi. No. 24. vol. vii. No. 25 (Stanford).—Annalen der Physik und Chemie, 1887, No. 8*b* (Leipzig).—Beiblätter u den Annalen der Physik und Chemie, 1887, No. 7 (Leipzig).

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